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(54) **BALL PLUNGER-STYLE CONNECTOR ASSEMBLY FOR ELECTRICAL CONNECTIONS**

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Related U.S. Application Data

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H01R 13/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01R 13/2421*** (2013.01); *H01R 13/2485* (2013.01)

(58) **Field of Classification Search**
USPC 439/700, 824, 17; 84/743
See application file for complete search history.

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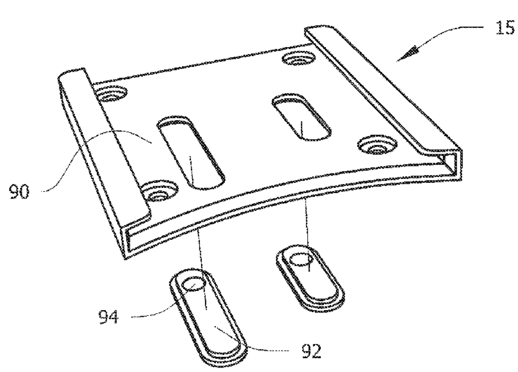
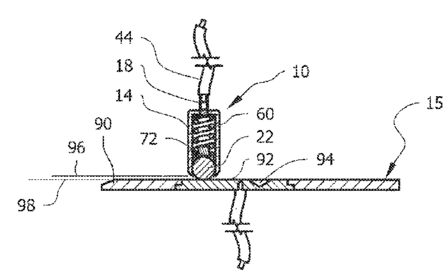
Primary Examiner — Alexander Gilman

(57) **ABSTRACT**

A ball plunger-style lateral connector assembly for electrical connections. One embodiment has an electrically conductive connector body with an electrically conductive pin extending into the body's interior area. An electrically conductive connector plate adjacent to the body's closed end engages the pin. An insulator sleeve in the body's interior area is adjacent to the body's sidewall. An electrically conductive biasing member in the interior area engages the connector plate; the insulator sleeve is between the biasing member and the connector body. An electrically conductive ball track in the interior area is in engagement with the other end of the biasing member. An electrically conductive ball is disposed in the body's open end and is seated in the ball track. The ball rolls within ball track during use of the lateral connector.

21 Claims, 6 Drawing Sheets





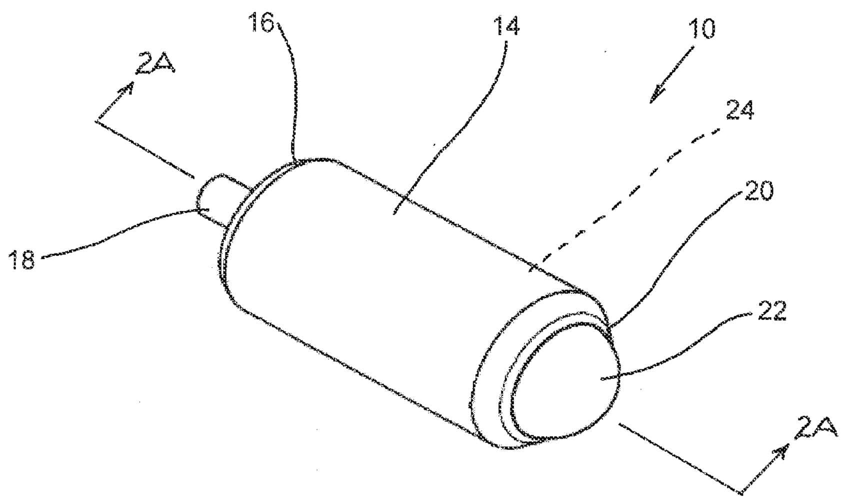


Figure 1A

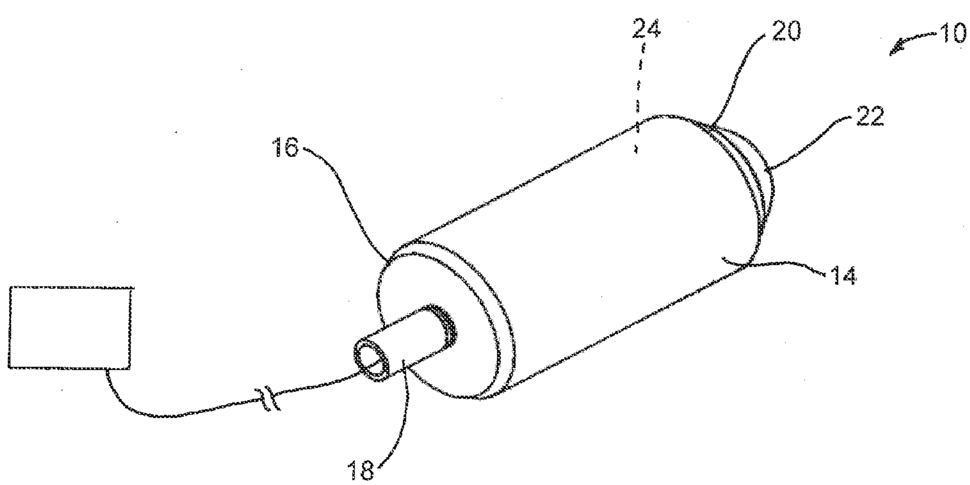


Figure 1B

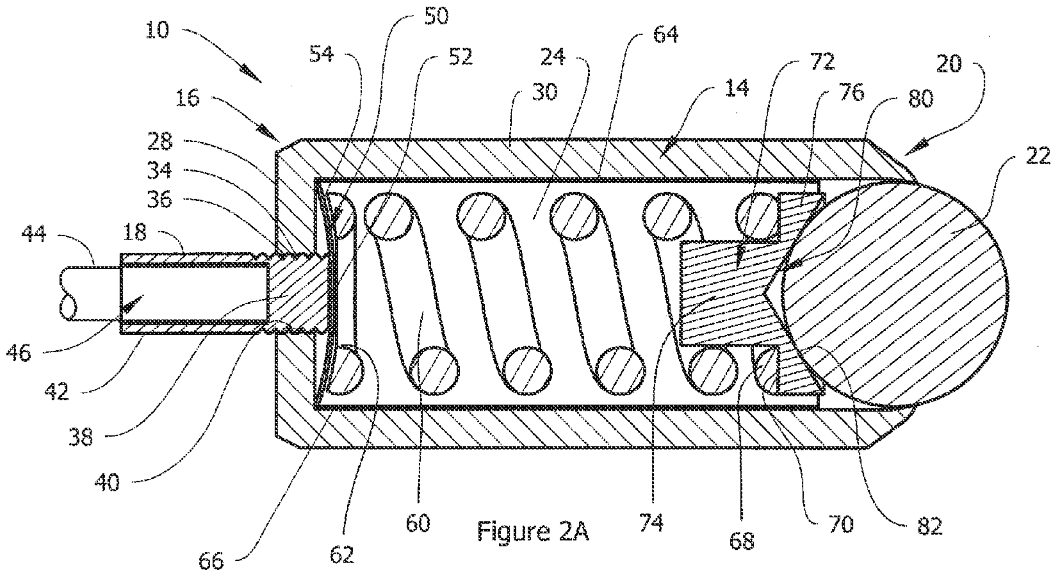


Figure 2A

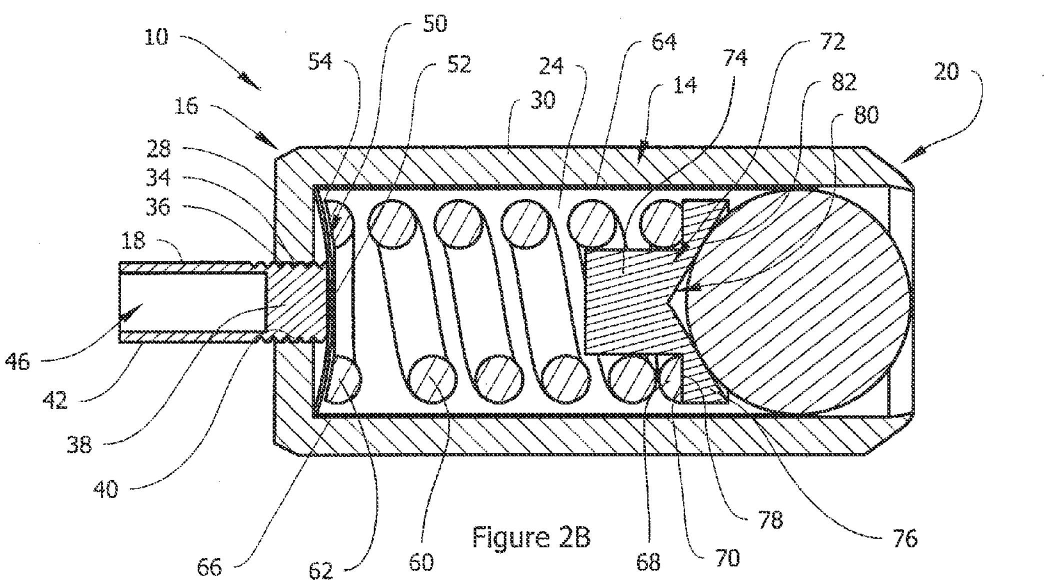


Figure 2B

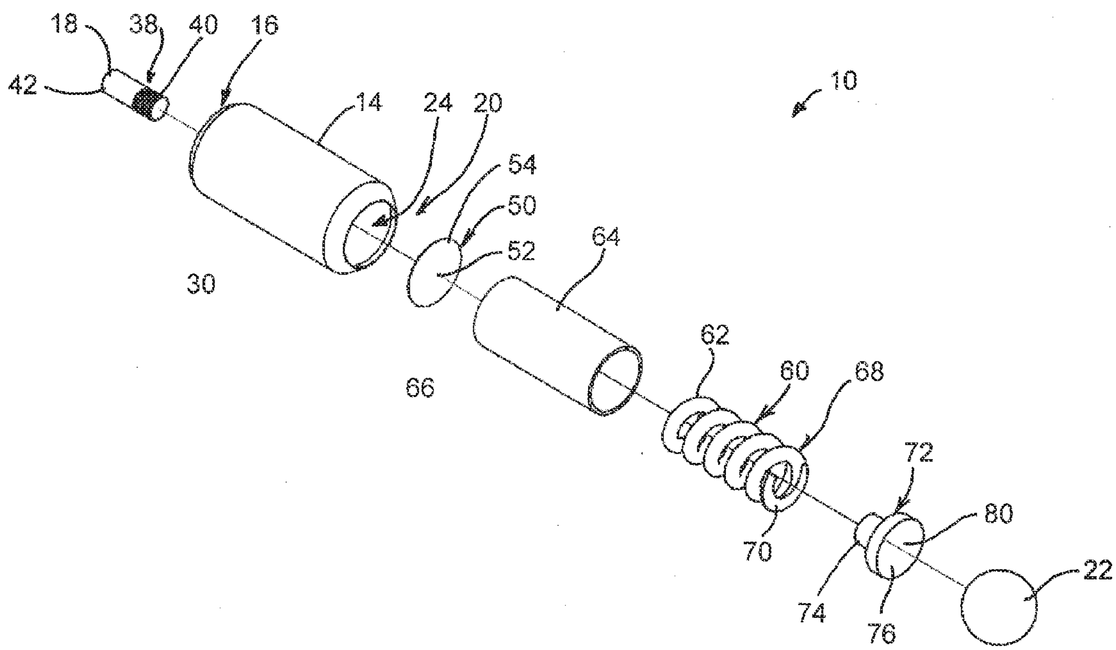


Figure 3

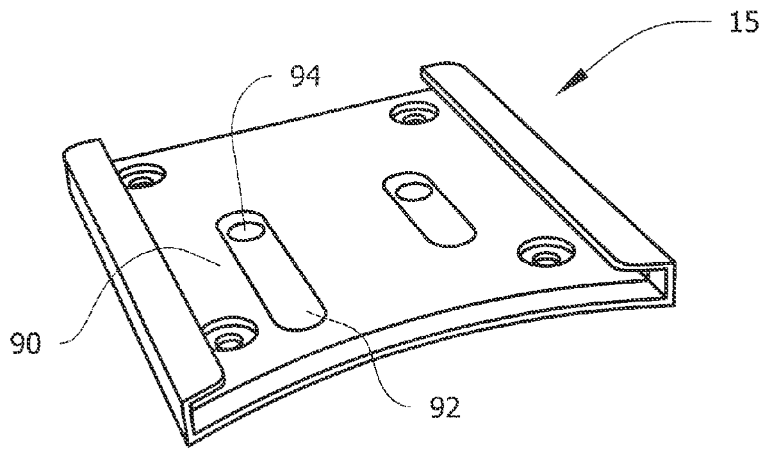


Figure 4A

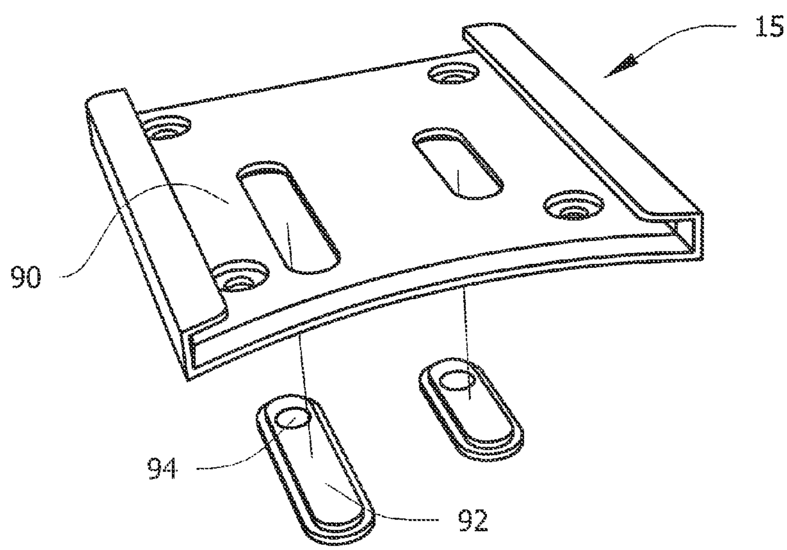


Figure 4B

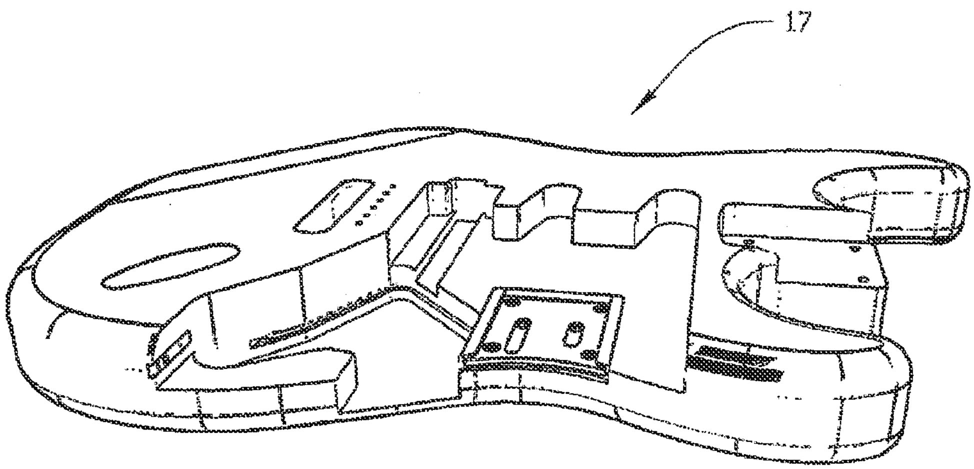


Figure 4C

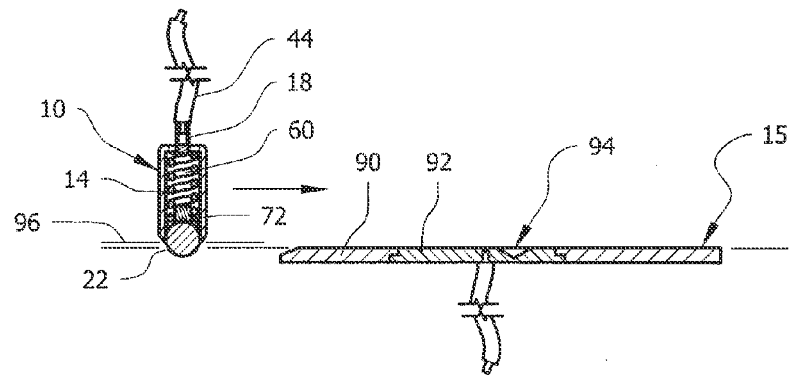


Figure 5A

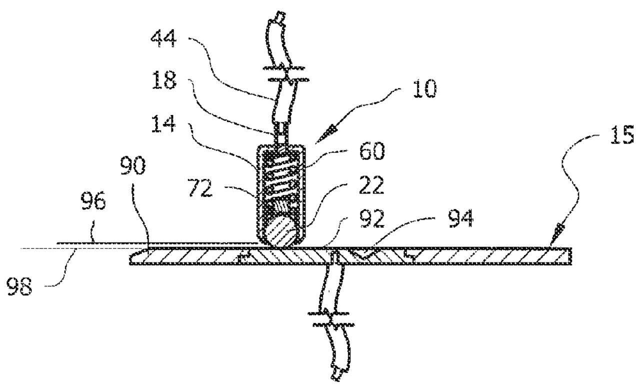


Figure 5B

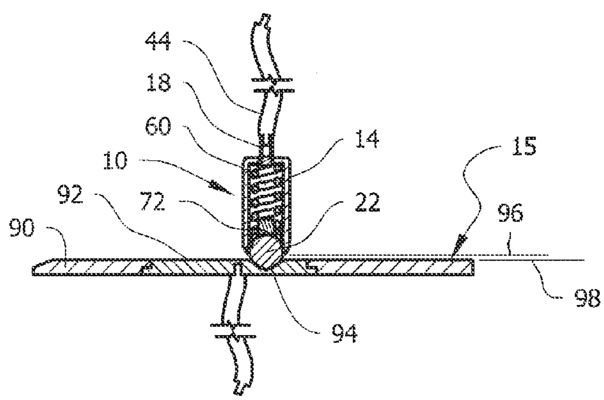


Figure 5C

BALL PLUNGER-STYLE CONNECTOR ASSEMBLY FOR ELECTRICAL CONNECTIONS

CROSS REFERENCE TO RELATED APPLICATION

The present application is a continuation patent of U.S. patent application Ser. No. 12/843,107, titled Ball Plunger-Style Connector Assembly for Electrical Connections, filed Jul. 26, 2010, which is a continuation-in-part of U.S. patent application Ser. No. 12/508,493, titled "Docking System For Pickups On Electric Guitars", filed Jul. 23, 2009, which is a continuation-in-part application of U.S. patent application Ser. No. 11/612,780, titled "Docking System For Pickups On Electric Guitars", filed Dec. 19, 2006, all of which are incorporated herein in their entirety by reference thereto.

TECHNICAL FIELD

Embodiments of the present invention are directed to electro-mechanical connectors.

BACKGROUND

Ball plungers have been used and mechanical detents in a variety of applications. Ball plungers are often used as a mechanical detent between two components that move laterally relative to each other between engaged and disengaged positions. Often times it is highly desirable to provide an electrical connection between to such components that move laterally relative to each other. There is a need for an improved ball plunger assembly that provides electrical connection between such components.

A ball plunger assembly has been used to provide mechanical and electrical interconnections between laterally disposable components of a docking system for pickups on electric guitars. As an example, Applicant's issued U.S. Pat. No. 7,538,269, issued May 26, 2009, titled "Docking Systems For Pickups On Electric Guitars," and issued U.S. Pat. No. 7,838,758, issued Nov. 23, 2010, titled "Docking Systems For Pickups On Electric Guitars," generally disclose a ball plunger assembly that acts as an electrical connector.

Testing of the electrical properties of these conventional ball plunger assemblies, however, confirmed that the conventional ball plungers could work to provide electrical and mechanical connections, but the ball plungers required improvement to achieve a reliable performance level required for a high quality electric instrument, such as the electric guitar or other musical instrument. Even the most promising samples of the conventional ball plunger assemblies containing all metal materials, such as 440 stainless steel balls, music wire spring material, and 303 stainless steel bodies (all conductive materials) produced unacceptably erratic and/or inconsistent resistance and conductance results.

While the conventional ball plungers provided for superior mechanical engagement for use in applications requiring lateral engagements, all of the conventional ball plungers that were electrically tested could not achieve the electrical performance requirements for use as a reliable, safe current carrier device. For example, conventional ball plungers have unacceptably erratic and unpredictable electrical resistance and conductance. Accordingly, the conventional ball plungers would be unacceptable and/or provide unreliable performance if used within electrical applications requiring superior reliability and performance. Therefore, the inventor has recognized performance limitations in the ball plunger assemblies and the need for substantial improvements in the ball plunger technologies.

SUMMARY

The present invention provides a ball plunger-style electrical connector assembly that overcomes drawbacks experienced in the prior art and that provide additional benefits. In an embodiment, the ball plunger-style electrical connector includes a body, an electrically conductive pin connected to the body and connectable to a wire or other electricity means, an electrically conductive connector plate within the body, an electrically conductive biasing member within the body, an electrically conductive ball track within the body and an electrically conductive ball partially disposed within the body and carried by the ball track. The connector assembly provides an improved electro-mechanical connecter for use, as an example, as a lateral connector.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a front isometric view of a ball plunger-style electrical lateral connector accordance with an embodiment of the present invention.

FIG. **1**B is a rear isometric view of the lateral connector of FIG. **1**A.

FIG. **2**A is an enlarged cross-sectional view of the lateral connector taken substantially along line **2-2** of FIG. **1**A, wherein the lateral connector is in an extended position.

FIG. **2**B is an enlarged cross-sectional view of the lateral connector of FIG. **2**A shown in a compressed position.

FIG. **3** is an enlarged exploded front isometric view of the lateral connector assembly of FIG. **1**A.

FIG. **4**A is an isometric view of a female connector portion, such as a connector plate, with a conductive receiving portion that mates with the lateral connector assembly of FIG. **1**A.

FIG. **4**B is a partially exploded isometric view of the connector plate of FIG. **4**A.

FIG. **4**C is an isometric view of the connector plate of FIG. **4**A shown positioned in the body of a musical instrument in accordance with an embodiment of the invention.

FIG. **5**A is a cross-sectional view of the lateral connector of FIG. **2**A and the connector portion of FIGS. **4**A-**4**C in a disengaged position during operation of the connector.

FIG. **5**B is a cross-sectional view of the lateral connector of FIG. **2**A and the connector portion of FIGS. **4**A-**4**C in an intermediate position during operation of the connector.

FIG. **5**C is a cross-sectional view of the lateral connector of FIG. **2**A and the connector portion of FIGS. **4**A-**4**C in an engaged position during operation of the connector.

DETAILED DESCRIPTION

The present disclosure describes a ball plunger-style electrical connector assembly in accordance with certain embodiments of the present invention. Several specific details of the invention are set forth in the following description and the Figures to provide a thorough understanding of certain embodiments of the invention. One skilled in the art, however, will understand that the present invention may have additional embodiments, and that other embodiments of the invention may be practiced without several of the specific features described below.

Embodiments of the present inventions include the ball plunger-style lateral connector for electrical connections on an installation assembly that slides or translates laterally relative to a mounting body between engaged and disengaged positions. The lateral connector is configured to provide electrical connection between electronic components on the installation and electronic components on the mounting body upon lateral translation to the installed position. Accordingly, the lateral connector can, as an example, provide for laterally actuated electrical male/female type connectors that complete a circuit between the electronic components. In addition, the lateral connector simultaneously acts as a mechanical retention device to removeably retain the installation assembly in the engaged position on the mounting body.

Some embodiments of the lateral connector are particularly well suited for use with high impedance, low voltage, low current devices. For example, an embodiment of the lateral connector can be incorporated in an improved docking system for pickups on electric guitars or other electric musical instruments. In such an embodiment, the lateral connector is configured to simultaneously provide electrical and mechanical connections upon lateral activation of, as an example, male/female type connectors without introducing additional mechanisms or interfering with or deviating from a natural interaction with the original instrument architecture or 'bloodline' of the instrument.

In an embodiment, a lateral connector assembly for electrical connections comprises an electrically conductive pin member operatively couplable to an electricity source. The pin member has first and second end portions. A connector body has an interior area, a closed end, an open end, and a sidewall extending between the closed and open ends. The closed end has an aperture with the pin member therein, and the first end portion of the pin member extends at least partially into the interior area of the connector body. A connector plate is in the interior area of the connector body and is positioned adjacent to the closed end of the connector body. The connector plate is electrically conductive and engages the first end portion of the pin member and provides an electrical connection therebetween. An insulator sleeve is disposed in the interior area of the connector body and adjacent to the sidewall of the connector body. An electrically conductive biasing member is disposed in the interior area of the connector body. The biasing member has a first end portion in engagement with the connector plate, and wherein the insulator sleeve is disposed between the biasing member and the connector body.

An electrically conductive ball track is positioned within the interior area of the connector body and is in engagement with a second end portion of the biasing member. The ball track has a concave seating portion that faces toward the open end of the connector body and that defines a rolling surface. An electrically conductive ball is disposed in the open end portion of the connector body and is seated in the concave seating portion of the ball track. The ball and ball track are configured to allow the ball to roll relative to connector body while maintaining engagement with the rolling surface of the ball track. The biasing member urges the ball track into engagement with the ball. The open end of the connector body is sized to retain the ball at least partially within the interior area. The ball is moveable with the ball track in the interior area toward the closed end of the connector body upon compression of the biasing member. The ball is configured to roll along a portion of the receiving member and to electrically engage the receiving contact portion while maintaining electrical contact with the ball track to achieve electrical interconnection between the pin member and the receiving member.

In another embodiment a lateral connector comprises an electrically conductive connection pin operatively couplable to an electricity source. A connector body has one end connected to the pin and an opposite open end. An electrically conductive connector plate is in the interior area of the connector body and is in engagement with an end portion of the pin. An electrically conductive biasing member is in the interior area of the connector body. The biasing member has a first end portion in engagement with the connector plate. An electrically conductive ball track is positioned within the interior area of the connector body and is in engagement with a second end portion of the biasing member. The ball track has a cup-shaped seating portion facing toward the open end of the connector body and defining a rolling surface. An electrically conductive ball is disposed in the open end portion of the connector body and is seated in the seating portion of the ball track with the ball track being between the ball and the biasing member. The ball and ball track are configured to allow the ball to roll relative to connector body while maintaining engagement with the rolling surface of the ball track. The biasing member urges the ball track into engagement with the ball, and the ball is moveable with the ball track into the interior area of the connector body upon compression of the biasing member.

In yet another embodiment, a ball plunger electrical connector is provided for engaging and completing electrical contact with a receiving member having an electrically conductive ball-receiving contact portion. The ball plunger electrical connector comprises an electrically conductive pin operatively couplable to an electricity source. The pin member has first and second end portions and is electrically conductive. The first end of the pin is threaded with first threads. A connector body has a closed end, an open end, and a sidewall extending between the closed and open ends, and an interior area. The closed end has a threaded aperture with second threads that mate with the first threads on the pin member. The pin member is screwed into the threaded aperture with at least a portion of the first end portion of the pin member extending from the closed end and at least partially into the interior area.

An electrically conductive connector plate is axially disposed in the interior area of the connector body and is positioned adjacent to the closed end of the connector body. The connector plate engages the first end portion of the pin member and provides an electrical connection therebetween. The connector plate has a partially concave shape with a concave portion facing toward the closed end of the connector body with the first end portion of the pin extending into the concave portion. An insulator sleeve is disposed in the interior area of the connector body and is adhered to an inner surface of the sidewall of the connector body. The insulator sleeve is configured to prevent electrical stray noise during use of the connector.

An electrically conductive beryllium copper coil spring is disposed in the interior area of the connector body. The spring has an interior space and a first end portion with a beveled flat portion that mates with a perimeter portion of the connector plate. The spring has a second end portion with a flattened engagement surface. An electrically conductive ball track is positioned within the interior area of the connector body and is in engagement with a second end portion of the biasing member. The ball track has a cup portion with a concave seating portion that faces toward the open end of the connector body and that defines a rolling surface. The ball track has a stem portion extending from the cup portion toward the closed end portion of the connector body. The cup portion defines an annular engaging shoulder adjacent to and extending radially outward from the stem portion. The flattened engagement surface of the second end portion of the spring is in constant engagement with the annular engaging shoulder. The stem portion is disposed with the interior space of the coil spring adjacent to the second end portion of the coil spring. The stem portion is sized to maintain a friction fit with the first end portion of the coil spring.

An electrically conductive ball is disposed in the open end portion of the connector body and is seated in the concave seating portion of the cup portion of the ball track. The ball and ball track are configured to allow the ball to roll relative to connector body while maintaining engagement with the rolling surface of the ball track. The spring urges the ball track into engagement with the ball. The ball has a first diameter, and the open end of the connector body defines a circular opening with a second diameter less than the first diameter. The open end portion of the connector body is sized to retain the ball at least partially within the interior area. The ball is moveable with the ball track in the interior area toward the closed end of the connector body upon compression of the spring. The ball is configured to roll along a portion of the receiving member and to electrically engage the receiving contact portion while maintaining electrical contact with the ball track when any portion of the ball is extending from the connector body to achieve electrical contact with the electrically conductive ball-receiving contact portion.

FIG. **1**A is a front isometric view of a ball plunger-style, lateral connector **10** accordance with an embodiment of the present invention, and FIG. **1**B is a rear isometric view of the lateral connector. In one embodiment, the lateral connector **10** is an electrically conductive assembly connectable to a power source **12** (shown schematically in FIG. **1**B) and configured to provide electrical and mechanical connections to a connector plate **15** (FIGS. **4**A and **4**B).

The lateral connector **10** includes a body **14** that connects at a rear end portion **16** to an electrically conductive pin connector **18** connectable to a wire or other electrically conductive member coupled to the power source **12** (FIG. **1**B). The body **14** has an open front portion **20** that retains an electrically conductive ball **22** at least partially within an interior area **24** of the body. The ball **22** is shown in FIGS. **1**A and **1**B in an extended position wherein the ball **22** at least partially protrudes through the open front portion **20** of the body **14**. The body **14** is sized so the ball **22** can be moved into the body's interior area **24** away from the extended position and toward the body's rear end portion **16**. As discussed in greater detail below, the ball **22** is biased toward the extended position to enable the lateral connector **10** to operate as a positive, releasable mechanical connector. Further, the ball **22** is electrically coupled to the pin connector **18** so as to conduct electricity from the power source **12** (FIG. **1**B) to the connector plate **15** (FIG. **4**A-**4**C). Accordingly, the lateral connector **10** can simultaneously act as a mechanical and electrical connector.

FIG. **2**A is an enlarged cross-sectional view of the lateral connector **10** taken substantially along line **2**A-**2**A of FIG. **1**A, and FIG. **3** is an enlarged exploded front isometric view of the lateral connector **10** of FIG. **1**A. In the illustrated embodiment, the body **14** of the lateral connector **10** is a cylindrical body with a closed rear end formed by a rear wall **28** integrally connected to a sidewall **30**. The rear wall **28** and the sidewall **30** define the interior area **24** of the body **14**.

The lateral connector **10** of the illustrated embodiment is an extremely high performance electrically connector. The electrically conductive body **14** is a machined phosphor bronze body. In other embodiments the body **14** can be made of another selected metal or other electrically conductive material (or combination of materials) suitable for the connector's performance requirements. In the illustrated embodiment, interior surfaces of the body **14** are polished to provide smooth, consistent surfaces for proper engagement with internal components within the interior area **24**. The polished interior surfaces help prevent or reduce stray electrical noise within the lateral connector **10** during use.

The rear wall **28** of the body **14** has an aperture **34** therein shaped and sized to receive a portion of the pin **18**. In the illustrated embodiment, the aperture **34** is approximately coaxially aligned with the longitudinal axis of the cylindrical body **14**. In addition, the aperture **34** includes a plurality of internal threads **36**. The pin connector **18** has a threaded engagement end **38** with external threads **40** that mate with the internal threads **36** in the aperture **34**. Accordingly, the pin **18** is securely connected to the body **14** by screwing the engagement end **38** of the pin into the rear wall **28** of the body **14**. This threaded engagement also provides for a secure and dependable electrical connection between the pin **18** and the body **14**. In the illustrated embodiment, the pin **18** is configured with the external threads **40** so that the engagement end **38** of the pin can extend fully through the aperture **34** and project a selected distance past the rear wall **28** into the interior area **24**.

The distal end portion **42** of the pin **18**, which remains exterior of the body **14**, is configured to connect to a wire **44** (FIG. **2**A) or other electricity carrier coupled to the power source **12** (FIG. **1**B). In the illustrated embodiment, the distal end portion **42** of the pin **18** has a hollow recess **46** that receives the end of the wire **44**. The hollow recess **46** is shaped and sized to snugly receive and engage the bare end of the wire **44**, while providing enough surface area to contact the wire to establish a reliable electrical connection. In one embodiment, the pin **18** is a gold-plated, hardened copper pin that provides the requisite electrical conductivity properties as well and suitable thermal conductivity properties. The pin **18** in other embodiments can be made of other suitable electrically conductive materials.

The configuration of the pin's distal end portion **42** and the engagement with the wire **44** facilitates a secure and reliable electrical connection by soldering the wire **44** to the pin **18** without damaging the lateral connector **10**. In one embodiment, the pin **18** can be soldered to the wire **44** before the pin **18** connected to the body **14**. For example, before the pin **18** is screwed into the body's rear wall **28**, the wire **44** is positioned into the hollow recess **46** and soldered in place to provide a positive mechanical and electrical connection with the pin. This soldering of the pin **18** to the wire **44** when the pin **18** is detached from the body **14** protects the body and the other internal components of the lateral connector **10** from the heat associated with soldering. Accordingly, the body **14** and the other internal components are protected from heat damage, such as warping, distortion, etc., that could occur if the wire **44** were soldered to the pin **18** when attached to the body **14**. Such heat damage could potentially compromise the integrity or performance of the lateral connector **10**.

In another embodiment, the lateral connector **10** may be configured for use in selected environments or situations wherein the performance requirements of the assembly allows the pin **18** to be soldered or otherwise securely fixed to the wire **44** when the pin **18** is connected to the body **14**. In another embodiment, the lateral connector **10** may be configured for use in selected environments or situations wherein the performance requirements allow the wire **44** to be soldered or otherwise securely fixed directly to the body **14** to obtain the electrical connection between the wire **44** and the body **13** without using the pin **18**.

The lateral connector **10** of the illustrated embodiment has an electrically conductive connector plate **50** axially disposed in the interior area **24** of the body **14** immediately adjacent to the rear wall **28** and in electrical contact with the pin **18**. In the illustrated embodiment, the connector plate **50** is a gold-plated, copper disc, although other suitably electrically conductive materials can be used in other embodiments. The connector plate **50** has a substantially circular cross-sectional shape with an outer diameter slightly less than the inner diameter of the body. The connector plate **50** fits snugly into the interior area **24**, with the perimeter of the connector plate immediately adjacent to and/or in engagement with the sidewall **30** of the body **14**. Accordingly, the sidewall **30** of the body **14** prevents or substantially limits lateral movement of the connector plate **50** within the interior area **24**.

Although the connector plate **50** of the illustrated embodiment is a circular, disc-shaped member that substantially corresponds to the cross-sectional shape of the body's interior area **24**, the connector plate **50** can have different shapers or sizes in other embodiments. For example, the interior area **24** of the body **14** may have a generally circular, elliptical, square, rectangular, polygonal, or other geometric or non-geometric cross-sectional shape, and the connector plate **50** can have a similar cross-sectional shape. In other embodiments the connector plate **50** can have a cross-sectional shape different than the cross-sectional shape of the body's interior area **24**, while still maintaining the performance requirements of the lateral connector **10**.

As shown in FIG. **2**A, the center portion **52** of the illustrated connector portion **50** securely engages the engagement end **38** of the pin **18** to provide a positive electrical connection between these components. In the illustrated embodiment, the center portion **52** of the connector plate **50** is spaced slightly apart from the rear wall **28** of the body **14** because the engagement end **38** of the pin **18** extends past the rear wall and into the body's interior area **24**. The connector plate **50** has a partially concave shape (relative to the pin **18** and the rear wall **28**), such that a perimeter portion **54** of the connector plate **50** is immediately adjacent to the rear wall **28**. In the illustrated embodiment, the perimeter portion **54** of the connector plate engages the rear wall and is positioned substantially within the corner area of the interior area **24** defined by the intersection of the rear wall **28** and the sidewall. **30**.

The lateral connector **10** includes an electrically conductive biasing member, shown as a coil spring **60**, disposed in the interior area **24** of the body **14**. The spring **60** is slightly compressed against the connector plate **50** so the rear end **62** of the spring **60** engages the connector plate's perimeter portion **54**. Accordingly, the rear end **62** of the spring **60** holds the connector plate **50** in firm engagement with the engagement end **38** of the pin **18**, and the spring **60** holds the connector plate's perimeter portion **54** in firm engagement with the rear wall **28** of the body **14**. Accordingly, the spring **60** can help maintain the concave shape of the connector plate **50** relative to the rear wall **28** and the pin **18**.

In some embodiments, the coil spring **60** may be susceptible to some buckling within the body when compressed, such that the spring **60** could contact or rub against the body's sidewall **30**, which could induce stray electrical noise during use of the lateral connector **10**. The lateral connector **10** of the illustrated embodiment is configured to avoid or reduce this stray electrical noise. The lateral connector **10** has an insulator sleeve **64** disposed in the body's interior area **24** immediately adjacent to the sidewall **30**, between the spring **60** and the body **14**. The insulator sleeve **64** has a bottom edge **66** that also engages the perimeter portion **54** of the connector plate **50**. Accordingly, the insulator sleeve **64** works with the spring **60** to securely hold the connector plate **50** in position within the body **14**.

In the illustrated embodiment, the insulator sleeve **64** has a high wet dielectric strength with excellent resistance to abrasion, moisture, alkalis, acid, copper corrosion, and varying weather conditions. In one embodiment, the insulator sleeve **64** is a poly vinyl chloride (PVC) tape adhered to the inner surface of the sidewall **30** of the connector body **14**. The PVC tape is placed around the interior surface of the body's sidewall **30** to provide a smooth interior surface adjacent to the spring **60**. In other embodiments, the insulator sleeve **64** can have other non-tape configurations, such as a non-conductive tubular member press fit into the body **14**. While the insulator sleeve **64** of the illustrated embodiment is made of PVC, the insulator sleeve **64** can be made of other non-conductive materials, such as other durable plastic materials with sufficient abrasion resistance at the interface with the spring **60**.

As indicated above, the center portion **52** of the connector plate **50** is positioned over the aperture **34** in the rear wall **28**. When the pin **18** is screwed into the rear wall **28** (i.e., after being soldered to the wire **44**), the pin's engagement end **38** advances into the interior area **24** and into engagement with the connector plate **50**. As the pin **18** is screwed in further, the engagement end **38** presses the center portion **52** of the connector plate **50** away from the rear wall **28**, while the spring **60** and/or the insulator sleeve **64** holds the perimeter portion **54** of the connector plate **50** against the rear wall **28**. This configuration allows the connector pin **18** to be used to increase or decrease the concave shape of the connector plate **50**.

In one embodiment, the connector pin **18** can be used with the connector plate **50** to adjust the compression and the resulting spring tension of coil spring **60** within the lateral connector **10**. This adjustment of the spring **60** can be used to increase or decrease the stiffness of the lateral connector **10** when moving into or out of engagement with the mating connector plate **15** (FIG. **1**B). This adjustable stiffness of the lateral connector **10** provides for an adjustable holding strength of the lateral connector **10** to maintain a mechanical engagement with the connector plate **15** (FIG. **1**B) or other mating component. The adjustable spring compression also allows for improved engagement and electrical conductance between the components within the lateral connector **10**.

The spring compression and the convex shape of the connector plate **50** (relative to the coil spring **60**; concave relative to the rear wall **28**) also provides for an improved electro-mechanical junction between the spring **60** and the connector plate **50**. For example, the perimeter portion **54** of the connector plate **50** defines a sloped engagement surface that engages the rear end **62** of the spring **60**. When the spring **60** is compressed and released during normal operation of the lateral connector **10** (i.e., when the lateral connector **10** is moved between the engaged and disengaged position), the rear end **62** of the spring **60** presses against the connector plate's sloped engagement surface. As the spring **60** presses against this sloped engagement surface, at least the rear end **62** of the spring **60** can undergo a slight increase in its diameter. This radial movement of the spring **60** against the connector plate **50** causes agitation to mating end surfaces of the connector plate **50** and spring **60**, thereby improving the electrical conductance between these components over time.

In the embodiments described above, the connector plate **50** is a disc-shaped member that can have a concave/convex shape. In another embodiment, the connector plate **50** can have other shapes and configurations while maintaining the electrical engagement with the spring **60**, the pin **18** and/or the body **14**. For example, the connector plate **50** can have a partially conical shape, wherein a portion of the connector plate extends partially into the interior of the spring **60**. This partially conical shaped connector plate can have a sloped engagement surface against which the rear end **62** of the spring **60** presses. In another embodiment, the connector plate can have a generally flat bottom surface that faces the rear wall **28** of the body **14** and that engages the pin **18**. The connector plate **50** may be configured to move axially within the body **14** when the pin **18** is screwed further through the rear wall **28** into the interior area **24**, thereby adjusting the spring tension and/or stiffness of the lateral connector **10**. The connector plate may also have a threaded aperture in a bottom face into which the threaded engagement end **38** of the pin **18** can be screwed, thereby securely holding the pin **18**, the body **14**, and the connector plate **50** together as a unit. In other embodiments, the connector plate **50** may have other shapes or configurations that provide the performance requirements for the lateral connector. **10**.

In the illustrated embodiment, the electrically conductive spring **60** is a gold-plated, beryllium copper spring. In other embodiments, the spring **60** can be made of another electrically conductive material that provides the desired electric conductivity and mechanical spring properties for the selected performance of the lateral connector **10**.

The spring **60** can have fabricated or otherwise shaped ends for optimized conductance between the components within the lateral connector **10**. For example, in the illustrated embodiment the rear end **62** of the spring **60** has a flattened surface beveled at an angle to substantially match the convex shaped engagement surface of the connector plate **50** to provide an optimized surface area of the spring's rear end **62** that is in contact with the connector plate **50**. In one embodiment, the flattened rear end **62** of the spring **60** and the connector plate **50** may be highly polished surfaces to avoid or substantially reduce oxidation and/or corrosion between the components. This optimized contact surface area provides optimized conductance between the spring **60** and the connector plate **50**.

An upper end **68** of the spring **60** is also configured with a flattened engagement surface **70** that mates with an electrically conductive ball track **72**. In the illustrated embodiment, the spring's upper end **68** has two-thirds of a flat ground coverage around the circumference of the spring **60** that defines the engagement surface **70**. In other embodiments, the spring's upper end **68** can have other shapes or configurations to properly mate with the ball track **72** or other component of the lateral connector **10** to provide a desired and/or optimized conductance between the components. The ball track **72** is positioned within the interior area **24** of the body **14** between the spring **60** and the ball **22** to allow for a smooth rolling action of the ball. If the ball **22** directly engaged the upper end **68** of the spring **60**, the ball **22** could bind against the spring **60** and not roll, particularly when the ball **22** is pressed hard against the spring. This binding of the ball **22** to prevent rolling could also result in marring and or otherwise causing excessive wear to the female connector plate **15** (FIG. **4**).

In the illustrated embodiment, the ball track **72** has a stem **74** extending rearwardly from a ball cup **76**, which sits atop the upper end **68** of the spring **60**. The stem **74** and the ball cup **76** are integrally connected to each other forming a unitary member. In other embodiments, the stem **74** may be a separate, non-integral component connected to the ball cup **76**. In the illustrated embodiment, the ball track **72** is made of gold plated, hardened copper, although the ball track **72** can be made of a molded synthetic graphite material, or other sufficiently durable, lubricious, conductive materials that will conduct the electricity between the spring **60** and the ball **22** while allowing the ball **22** to roll within the ball cup **76**.

The stem **74** of the illustrated ball track **72** is a generally cylindrical portion with an outer diameter slightly greater than the inside diameter within the spring **60** (when the spring is in a relaxed state). When the ball track **72** is assembled with the spring **60**, the stem **74** is pushed into the spring's interior area, causing the upper end **68** of the spring **60** to slightly expand radially to receive the stem **74**. Accordingly, the upper end **68** of the spring **60** is configured to grab and frictionally hold the stem **74** to maintain a secure juncture between the ball track **72** and the spring **60**, while maintaining the required conductance between these electrical conductors.

The ball cup **76** is coaxially aligned with the stem **74** and the spring **60**, and the ball cup **76** has a generally flat bottom surface **78** from which the stem projects. The flat bottom surface **78** extends around the stem **72** and forms a generally flat, annular engagement area that securely engages the flattened engagement surface **70** of the spring **60** to provide the mechanical and electrical interconnection between the components while optimizing conductance between these components. In one embodiment, the flat bottom surface **78** and/or the spring's flattened engagement surface **70** can be polished surfaces that help avoid oxidation and/or corrosion between the components.

The ball cup **76** has an outer diameter approximately the same or slightly greater than the outer diameter of the spring **60**, so the ball cup sits firmly atop the spring and maintains a substantially perpendicular arrangement relative to the spring. In the illustrated embodiment, the outer edge of the ball cup **76** is immediately adjacent to the top of the insulating sleeve **64** so that the insulating sleeve **64** helps maintain a perpendicular alignment of the ball track **72** as it moves axially within the body's interior area **24** during use of the lateral connector **10**. The stem **74** also helps maintain this perpendicular alignment of the ball track **72** on the spring **60** and within the body **60**, particularly when the ball track **72** and ball **22** are moved axially within the body **14** during use of the lateral connector **10**.

The upper portion of the ball cup **76** includes a concave seating portion **80** that faces toward the open front portion **20** of the body **14** and that defines a rolling surface **82** on the ball track **72** along which the ball **22** can roll during use of the lateral connector **10**. The rolling surface **82** and the ball **22** are made of sufficiently lubricious materials so that the friction between the components can be easily overcome to allow the surface of the ball **22** to slide against the rolling surface **82** as the ball **22** rolls within the ball cup **76**. In one embodiment, the ball **22** is a gold plated, electro polished, **440** stainless steel ball having a precision grade with high concentricity, hardness rating, and surface finish. This gold plated ball **22** rolls easily against the gold-plated, hardened copper ball cup **76** and provides excellent electrical conductance between the components.

The spring **60** is also balanced with the ball cup **76** and the ball **22**, so that the spring **60** will push against the ball cup **76** and keep the seating portion **80** in secure engagement with the ball **22**. The spring **60**, however, is configured so that it provides a normal force between the ball **22** and the seating portion **80** that is low enough so the ball **22** can still easily roll against the rolling surface **82** during use of the lateral connector **10**. If the spring stiffness is too great, the normal force between the ball **22** and the ball cup **76** may be too large so as to create an excessive resistance to the ball **22** rolling within the ball cup **76** during use of the lateral connector **10**.

In the illustrated embodiment, the concave seating portion **80** has a generally V-shaped cross-sectional shape so that the ball **22** is constantly in physical contact along an annular contact path that defines the rolling surface **82**. In at least one embodiment, the ball **22** and the ball cup **76** are configured so that, over time, the ball **22** can wear into the rolling surface **82** just enough to increase the width of the annular contact path between the ball **22** and the seating portion **80**. This wider annular contact path provides for a greater surface area contact between the ball **22** and the ball cup **76**. Accordingly, the electrical conductivity performance of the lateral connector **10** can increase over time as the ball **22** and the rolling surface **82** work together to widen the annular contact path. In another embodiment, the ball cup **76** can be machined or otherwise formed with an integral annular contact path with a shallow arcuate channel formed in the rolling surface **82** to create the annular ring into which the ball **22** will sit and roll during use of the lateral connector **10**.

While the illustrated embodiment is constructed with a generally V-shaped seating portion **80**, other embodiments can have a seating portion **80** with a different cross-sectional shape. For example, the seating portion **80** may have a partially spherical cross-sectional shape with a radius greater than the radius of the ball **22** so the ball will sit in the seating portion **80** and be able to roll against the partially spherical rolling surface. In another embodiment, the concave seating portion **80** can have a partially spherical cross-sectional shape with a radius substantially the same as the radius of the ball **22**. In this embodiment, the ball **22** may contact substantially the entire seating portion **80**.

As shown in FIG. **2**A, when the ball **22** is in an extended position, at least a portion of the ball **22** is positioned within the interior area **24** of the body **14**, and another portion of the ball **22** projects through the open front portion **20** of the body **14**. In the illustrated embodiment, the open front portion **20** of the body **14** is crimped or otherwise formed to define a mouth having a diameter less than the diameter of the ball **22**. Accordingly, less than half of the ball **22** is exterior of the body **14** when the ball is in the extended position. In this extended position, the spring **60** urges the ball **22** toward the extended position, and the crimped open front portion **20** of the body **14** prevents the ball **22** from being fully ejected from the body **14**.

As shown in FIG. **2**B, the ball **22** can be moved to a compressed position upon a normal force pushing against the ball **22**, which causes the spring **60** to compress within the body **14** so the ball **22** and the ball track **72** move axially and rearwardly into the interior area **24** of the body **14**. The ball **22** and ball track **72** are configured so the ball **22** can roll within the ball cup **76** as the ball is being moved between the extended and compressed positions. Further, the electrically conductive ball **22**, ball track **72**, spring **60**, connector plate **50** and the pin **18** all remain in secure physical contact with each other to ensure the electrical conductivity of the lateral connector **10** is always maintained during rolling or axial movement of the ball between the extended and compressed positions.

In the illustrated embodiment, the open front portion **20** of the body **14** is crimped after the ball **22** and other components are assembled within the body **14**. In other embodiments, a collar or other retention mechanism may be connected to the open front portion **20** of the body **14** to retain the ball **22** within the body **14** when in the extended position.

The lateral connector **10** of the illustrated embodiment described above provides a high performance connector configured for use within specific electrical and mechanical performance requirements, such as for use with an electric guitar or other musical instrument. The illustrated embodiment provides a laterally actuated connector **10** that has a maximum target resistance of 0.005 KΩ. In addition, the internal components of the lateral connector **10** are provided with polished or otherwise very smooth contact surface, because rough or uneven contact surfaces diminish the ability of the components to maintain an adequate electro-mechanical junction to achieve the performance requirements. Further, rough or uneven contact surfaces can promote oxidation and corrosion, which can diminish the electrical and/or mechanical performance of the lateral connector **10**.

The following provides an example of operation of the lateral connector **10** in accordance with an embodiment for purposes of illustration. FIG. **4**A is an isometric view of the connector plate **15** with a conductive receiving portion that mates with the lateral connector assembly of FIG. **1**A. The connector plate **15** of the illustrated embodiment has two conductive receiving portions, so that the connector plate **15** can simultaneously engage (mechanically and electrically) two lateral connectors. FIG. **4**B is a partially exploded isometric view of the connector plate of FIG. **4**A with the conductive receiving portions shown relative to a non-conductive plate portion. FIG. **4**C is an isometric view of the connector plate **15** of FIG. **4**A shown positioned in the body of **17** a musical instrument, such as a guitar body, in accordance with an embodiment of the invention. FIG. **5**A is a cross-sectional view of the lateral connector **10** and the connector plate **15** of FIGS. **4**A and **4**B in a disengaged position during operation. In the illustrated embodiment, the connector plate **15** is a plate used on an electric guitar, such as the type shown in applicant co-pending U.S. patent application Ser. No. 12/508493 (Publication No. 2010-0031800), titled "Docking System For Pickups On Electric Guitars," and the lateral connector **10** can be connected to the pickup assembly described therein to provide electrical and mechanical connection between the guitar and the pick up assembly. While this example is described in connection with the guitar and pickup assembly, one skilled in the art will recognize that the lateral connector **10** can be used with an electrical connector in other arrangements to provide the electrical and mechanical connection between the desired components.

In this illustrated embodiment, the connector plate **15** is a generally planar alignment guide with a substantially flat engagement portion **90** configured to electrically and mechanically engage the ball **22** of the lateral connector **10**. At least a portion of the engagement portion **90** is electrically conductive and is coupled to an electrical component to which electricity is delivered. The engagement portion **90** has a non-conductive plate portion that receives two electrically conductive receiving portions that each define a flat roll-way area **92** along which the ball **22** of the lateral connector **10** can roll, and a concave receiving portion **94** shaped and sized to receive the ball **22** when the lateral connector **10** is in an engaged position with the connector plate **15**. In the illustrated embodiment, the concave receiving portion **94** can have a substantially V-shaped cross-sectional shape, a partially spherical shape, or other concave shape that allows the ball **22** to smoothly roll or otherwise and move into and out of the concave receiving portion **94**.

During operation, when the lateral connector **10** is in the disengaged position and is to be moved into engagement with the connector plate **15**, the lateral connector **10** begins in a position laterally offset from the connector plate **15** and is substantially perpendicular relative to the roll-way portion **92**. In the illustrated embodiment (as shown in FIGS. **4**A-**4**C), the connector plate **15** has the two roll-way portions, which are of different lengths. The lengths of the conductive roll-way portions **92** are used to control when the associated lateral connector **10** may first establish electrical engagement between the components when two lateral connectors are simultaneously engaged with the connector plate **15**. The open front portion **20** of the body **14** is in a plane **96** that is spaced apart from and substantially parallel with a plane **98** of the surface of the engagement portion **90**. Accordingly, the ball **22** extends through the plane **98** of the engagement portion **90** when the lateral connector **10** is in the disengaged position.

As the lateral connector **10** is moved laterally relative to the connector plate **15** toward an intermediate position, shown in FIG. **5**B, the ball **22** is moved into engagement with the connector plate **15**, such that the connector plate **15** pushes the ball **22** and the ball track **72** axially into the body **14** so as to compress the spring **60** until the ball **22** is in the compressed position, as discussed above. As the lateral connector **10** moved further laterally, the ball **22**, in the compressed position, engages and rolls along the flat roll-way area **92** of the engagement portion **90** toward the concave receiving portion **94**. During this lateral movement, when the ball **22** is in contact with the roll-way area **92** and/or the concave receiving portion **94**, the lateral connector **10** is electrically connected to the connector plate **15**.

The lateral connector **10** is moved laterally along the roll-way area **92** until the lateral connector **10** is in the engaged position (shown in FIG. **5**C) with the ball **22** coaxially aligned with the concave receiving portion **94**. As the lateral connector **10** moves into this engaged position, the ball **22** rolls into alignment with the concave receiving portion **94**, and the spring **60** urges the ball track **72** and the ball **22** away from the compressed position toward the extended position so the ball **22** drops into the concave receiving portion **94**. When the lateral connector **10** is in this engaged position the ball **22** is firmly seated in the concave receiving portion **94** while maintaining electrical contact therebetween. In addition, the spring **60** firmly holds the ball **22** within the concave receiving portion **94** and resists lateral movement of the lateral connector **10** away from this engaged position. Accordingly, the lateral connector **10** retains the positive mechanical connection with the connector plate **15**.

The lateral connector **10** will stay mechanically and electrically engaged with the connector plate **15** until a sufficiently large lateral force is exerted on the lateral connector **10** and/or the connector plate **15** to cause the spring **60** to compress and the ball **22** to roll out of the concave receiving portion **94** and toward the compressed position, so that the lateral connector **10** can moves toward the intermediate position and/or the disengaged position. As indicated above, the spring **60** can be selected and/or adjusted to control the amount of lateral force needed to move the lateral connector **10** out of engagement with the connector plate **15**. This configuration provides a ball plunger-style electrical connector that provides for releasable mechanical connection with the connector plate while simultaneously providing an electrical connection with the connector plate suitable for use in, as an example, an electric guitar that requires a reliable, repeatable, precision electrical interface without detracting from the bloodline of the musical instrument.

From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various modifications may be made without deviating from the invention. While embodiments discussed above were configured for use with high impedance, low voltage, low current devices, the lateral connector is not limited to use with such devices, and can be constructed to accommodate lower impedance, higher voltage, and/or higher current devices. Additionally, aspects of the invention described in the context of particular embodiments or examples may be combined or eliminated in other embodiments. Although advantages associated with certain embodiments of the invention have been described in the context of those embodiments, other embodiments may also exhibit such advantages. Additionally, not all embodiments need necessarily exhibit such advantages to fall within the scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

I claim:

1. An electrical connector assembly, comprising:

first and second support members movable relative to each other between a mechanically engaged position and a disengaged position;

a receiving member attached to the first support member, the receiving member having a receiving contact portion;

a pin member operatively couplable to an electricity source, the pin member having first and second end portions and being electrically conductive;

a connector body fixedly attached to the second support member, the connector body having a closed end, an open end, a sidewall extending between the closed and open ends, and an interior area, the closed end having an aperture having the pin member therein with the first end portion of the pin member extending at least partially into the interior area;

a connector plate positioned adjacent to the closed end of the connector body, the connector plate engaging the first end portion of the pin member and providing an electrical connection therebetween;

an insulator sleeve in the interior area of the connector body;

an electrically conductive biasing member disposed in the interior area of the connector body, the biasing member having a first end portion in engagement with the connector plate, and wherein the insulator sleeve is between the biasing member and the connector body;

an electrically conductive ball track in engagement with a second end portion of the biasing member, the ball track having a concave seating portion facing toward the open end of the connector body and defining a rolling surface; and

an electrically conductive ball in the open end portion of the connector body and seated in the concave seating portion of the ball track, the ball and ball track being configured to allow the ball to roll relative to the connector body while maintaining engagement with the rolling surface of the ball track, the biasing member urging the ball track into engagement with the ball, the open end of the connector body being sized to retain the ball at least partially within the interior area, and the ball being moveable with the ball track in the interior area toward the closed end of the connector body upon compression of the biasing member, the ball being configured to roll along a portion of the receiving member and to electrically engage the receiving contact portion while maintaining electrical contact with the ball track to achieve electrical interconnection between the pin member and the receiving member.

2. The electrical connector assembly of claim **1** wherein the second end portion of the pin member having a wire-receiving bore configured to operatively receive an electrically conductive wire therein to establish electrical connection with the wire.

3. The electrical connector assembly of claim **1** wherein the first end portion of the pin has threads thereon, and the aperture in the closed end of the connector body is threaded, wherein the first end portion of the pins is screwed into the closed end of the connector body for a secure threaded engagement therebetween.

4. The electrical connector assembly of claim **1** wherein the open end of the connector body has a diameter less than a diameter of the ball and is sized to allow a portion of the ball to project therefrom while preventing more than one-half of the ball from exiting the interior area.

5. The electrical connector assembly of claim **1** wherein the electrically conductive biasing member is compressible to allow the ball and the electrically conductive ball track to move as a unit within the interior area while maintaining electrical connection with the biasing member, the connector plate and the pin member.

6. The electrical connector assembly of claim **1** wherein the connector body is a substantially cylindrical member axially aligned with the connector plate, the insulator sleeve, the biasing member, the ball track and the ball.

7. The electrical connector assembly of claim **1** wherein the connector plate has a concave-shape that defines a concave area that faces toward the closed end of the connector body, and the first end portion of the pin member extends into the concave area of the connector plate and engages a central portion of the connector plate.

8. The electrical connector assembly of claim **1** wherein the first end portion of the pin member projects past the closed end of the connector body and into the interior area, and the insulator sleeve or the biasing member presses against the connector plate to retain a perimeter portion of the connector plate adjacent to the closed end of the connector body with the connector plate being retained in a concave shape.

9. The electrical connector assembly of claim **1** wherein the electrically conductive biasing member is a coil spring with a flattened engagement surface engaging a mating portion of the ball track to maintain electrical connection therebetween.

10. The electrical connector assembly of claim **1**, wherein the electrically conductive biasing member is a beryllium copper coil spring.

11. The electrical connector assembly of claim **10**, wherein the coil spring has a first end engaging the ball track and a second end engaging the connector plate.

12. The electrical connector assembly of claim **10**, wherein the coil spring has a first end engaging the ball track and a second end engaging the connector plate, the connector plate having a concave shape and a perimeter portion, the second end having a beveled flat portion that mates with the perimeter portion of the connector plate.

13. The electrical connector assembly of claim **1** wherein the biasing member is a coil spring with a first end portion and interior space with a generally cylindrical shape, and the electrically conductive ball track has a cup portion that receives the ball and a stem portion extending from the cup portion, the cup portion defining an annular engaging shoulder adjacent to and extending radially outward from the stem portion, the first end portion of the coil spring being in constant engagement with the annular engaging shoulder, and the stem portion is disposed with the interior space of the coil spring adjacent to the first end portion of the coil spring, the stem portion being sized to maintain a friction fit with the first end portion of the coil spring.

14. The electrical connector assembly of claim **13** wherein the ball has a spherical outer surface, and the cup portion has a spherical inner surface that substantially matches the spherical outer surface and is configured to minimize electrical resistance between the spherical inner and outer surfaces and reducing friction therebetween to allow the ball to roll within the cup portion along the spherical inner surface.

15. A ball plunger electrical connector, comprising:

first and second support members movable relative to each other between a mechanically engaged position and a disengaged position;

a receiving member attached to the first support member, the receiving member having a receiving contact portion;

an electrically conductive connection pin operatively couplable to an electricity source, the pin member having an end portion;

a connector body attached to the second support member, the connector body having one end connected to the pin and having an open end opposite the one end, the connector body having an interior area;

an electrically conductive connector plate in the interior area and in engagement with the pin and providing an electrical connection therebetween;

an electrically conductive biasing member in the interior area and in engagement with the connector plate;

an electrically conductive ball track positioned within the interior area and in engagement with a second end portion of the biasing member, the ball track having a cup-shaped seating portion facing toward the open end of the connector body and defining a rolling surface; and

an electrically conductive ball in the open end portion of the connector body and seated in the seating portion of the ball track with the ball track being between the ball and the biasing member, the ball and ball track being configured to allow the ball to roll relative to connector body while maintaining engagement with the roping surface of the ball track, the biasing member urging the ball track into engagement with the ball, and the ball being moveable with the ball track into the interior area of the connector body upon compression of the biasing member.

16. The ball plunger electrical connector of claim **15**, further comprising an insulator sleeve between the biasing member and a sidewall of the connector body.

17. The ball plunger electrical connector of claim **15** wherein the open end of the connector body had a diameter less than a diameter of the ball.

18. The ball plunger electrical connector of claim **15** wherein the connector plate has a concave-shape that defines a concave area that faces toward the closed end of the connector body, and the pin member engages a central portion of the connector plate.

19. The ball plunger electrical connector of claim **15** wherein the biasing member is a partially compressed coil spring with a flattened engagement surface engaging a mating portion of the ball track to maintain electrical connection therebetween.

20. The ball plunger electrical connector assembly of claim **15** wherein biasing member is a coil spring with a first end portion and interior space with a generally cylindrical shape, and the electrically conductive ball track has a cup portion that receives the ball and a stem portion extending from the cup portion, the cup portion defining an annular engaging shoulder adjacent to and extending radially outward from the stem portion, the first end portion of the coil spring being in constant engagement with the annular engaging shoulder, and the stem portion is disposed with the interior space of the coil spring adjacent to the first end portion of the coil spring, the stem portion being sized to maintain a friction fit with the first end portion of the coil spring.

21. A ball plunger electrical connector, comprising:

first and second support members movable relative to each other between a mechanically engaged position and a disengaged position;

a receiving member attached to the first support member, the receiving member having an electrically conductive ball-receiving contact portion

an electrically conductive pin operatively couplable to an electricity source, the pin member having first and second end portions and being electrically conductive, the first end being threaded with first threads;

a connector body connected to the second support member, the connector body having a closed end, an open end, a sidewall extending between the closed and open ends, and an interior area, the closed end having a threaded aperture with second threads that mate with the first threads, the pin member being screwed into the threaded aperture with at least a portion of the first end portion of the pin member extending from the closed end and at least partially into the interior area;

an electrically conductive connector plate axially adjacent to the closed end of the connector body, the connector plate having a partially concave shape with a concave portion facing toward the closed end of the connector body with the first end portion of the pin extending into the concave portion;

an insulator sleeve adhered to an inner surface of the sidewall;

an electrically conductive beryllium copper coil spring disposed in the interior area of the connector body, the spring having an interior space and a first end portion with a beveled flat portion that mates with a perimeter portion of the connector plate, the spring having a second end portion with a flattened engagement surface;

an electrically conductive ball track positioned within the interior area of the connector body and in engagement with a second end portion of the biasing member, the ball track having a cup portion with a concave seating portion facing toward the open end of the connector body and defining a rolling surface, the ball track having a stem portion extending from the cup portion toward the closed end portion of the connector body, the cup portion defining an annular engaging shoulder adjacent to and extending radially outward from the stem portion, the flattened engagement surface of the second end portion of the spring being in constant engagement with the annular engaging shoulder, and the stem portion is disposed within the interior space of the coil spring adjacent to the second end portion of the coil spring, the stem portion being sized to maintain a friction fit with the first end portion of the coil spring;

an electrically conductive ball disposed in the open end portion of the connector body and seated in the concave seating portion of the cup portion of the ball track, the ball and ball track being configured to allow the ball to roll relative to connector body while maintaining engagement with the rolling surface of the ball track, the spring urging the ball track into engagement with the ball, the ball having a first diameter and the open end of the connector body defining a circular opening with a second diameter less than the first diameter, wherein the open end portion of the connector body sized to retain the ball at least partially within the interior area, and the ball being moveable with the ball track in the interior area toward the closed end of the connector body upon compression of the spring, the ball being configured to roll along a portion of the receiving member and to electrically engage the receiving contact portion while maintaining electrical contact with the ball track when any portion of the ball is extending from the connector body to achieve electrical contact with the electrically conductive ball-receiving contact portion.

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